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Review of a Rolling Lift Bridge

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REVIEW

OF A

ROLLING LIFT BRIDGE

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JOHN EDWARD KEMP

THESIS

FOR THE DEGREE OF BACHELOR OF SCIENCE

IN CIVIL ENGINEERING

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REVIEW OF

THE DESIGN OF A ROLLING LIFT BRIDGE

In the choice of a subject for a thesis, a student in an engineering course should be influenced by the economic importance of the subject chosen. It will be of great advantage to him if his thesis is along some line of work that is certain of a prominent place in the future achievements of his profession. The design and construction of movable lift bridges is one of the important problems in civil engineering, and for that reason the author has chosen for his thesis, a review of the design of a rolling lift bridge.

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TYPE-FORMS OF MOVABLE BRIDGES

The most prominent type-forms of movable bridges are the swing and the bascule. A swing bridge is a structure consisting of two cantilever trusses balanced about a central frame-work which revolves about a center pier. The term, bascule bridge, includes all bridges worked by counterpoise, and whose motion takes place in a vertical plane. There are two varieties; the trunnion bascule, and the rolling lift bridge. Each is composed of one or two leaves according to the span desired, and each leaf consists of a cantilever truss which projects over the stream and is balanced by the counter-weights. The difference between these two types of bascule bridge is in the point of support. In the trunnion bascule the leaf is balanced about a pin,

while in the rolling lift bridge it is balanced on a circular segmental girder. The revolution of the leaf about this segmental girder produces a rolling back of the entire leaf, which motion is the essential and distinguishing characteristic of the rolling lift bridge.

The swing bridge, in all probability, has reached its highest degree of developement. Preceding the invention of the modern bascule bridges, it was the only efficient movable bridge, and over ninty percent of the bridges built between 1850 and 1895, to provide a passage over a navigable stream for street or railway traffic, are of the swing type. It is only within the last ten years that the rolling lift bridge has been invented and developed. This rolling lift type is especially well adapted for cities like

Chicago or Milwaukee, where traffic is congested on the streets crossing a navigable waterway. It possesses advantages which belong to no other bridge and has none of the serious defects of the swing bridge. A study of the different types of movable bridges will show the superiority of the rolling lift bridge.

At the time the author was making his choice of a thesis subject, there had just been completed in Chicago a rolling-lift highway bridge over the Chicago river at Taylor street. This structure was representative of the latest and best practice in this type of movable bridge, and for that reason the writer decided to present a review of that structure in his thesis.

DESCRIPTION OF THE BRIDGE

The rolling lift bridge over the Chicago river at Taylor street was built according to details of plans furnished by the Sanitary District of Chicago under the Scherzer Rolling Lift Bridge patents. The movable span is one hundred and forty-eight feet seven inches, center to center of bearings; and the roadway is twenty feet four inches, center to center of trusses, with a five-foot sidewalk on each side. The bridge was designed, according to the specifications of the Scherzer Rolling Lift Bridge Company and Cooper's Specifications for Highway Bridges, to act as a cantilever, the live-load stresses being carried by means of anchorages to the rear of the supporting piers. It is to carry

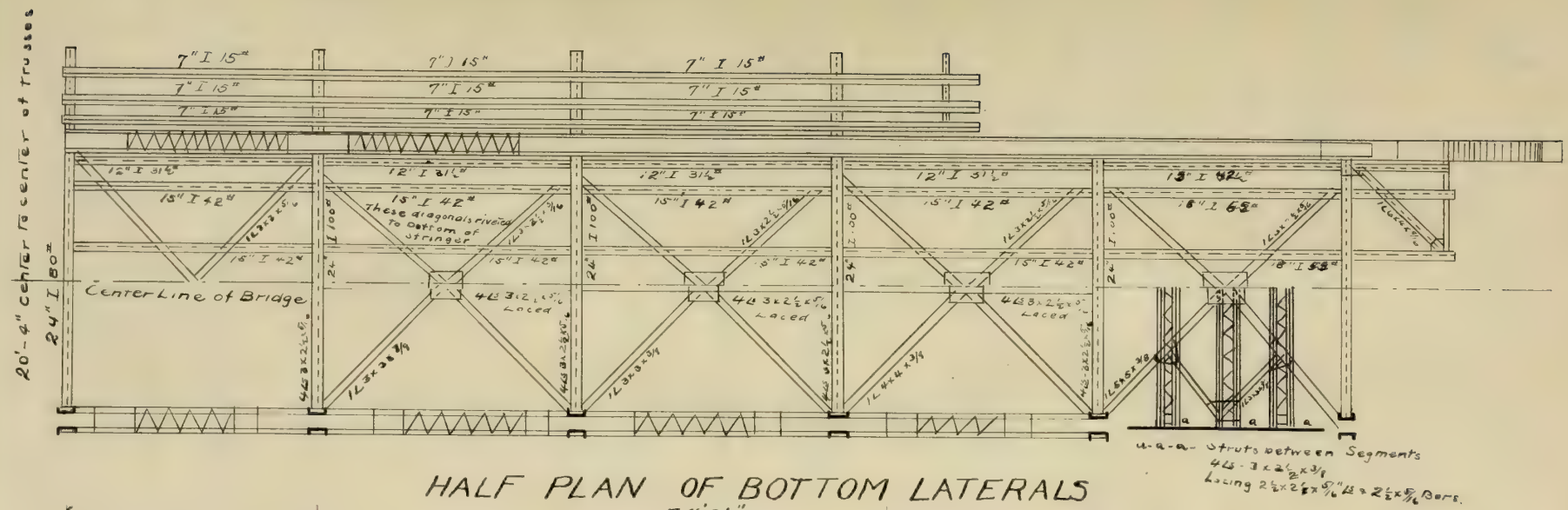
the heaviest highway and street-car traffic. The elevation of the road way above water is about thirty feet, permitting the bridge to be designed as a deck span with an arched bottom chord. The bridge need not be opened for the passage of tugs or any but masted vessels.

This bridge crosses the Chicago river at an angle of seventy-four degrees, and provides a clear channel for navigation of one hundred and twenty feet between pier protections, at right angles to the center line of the channel.

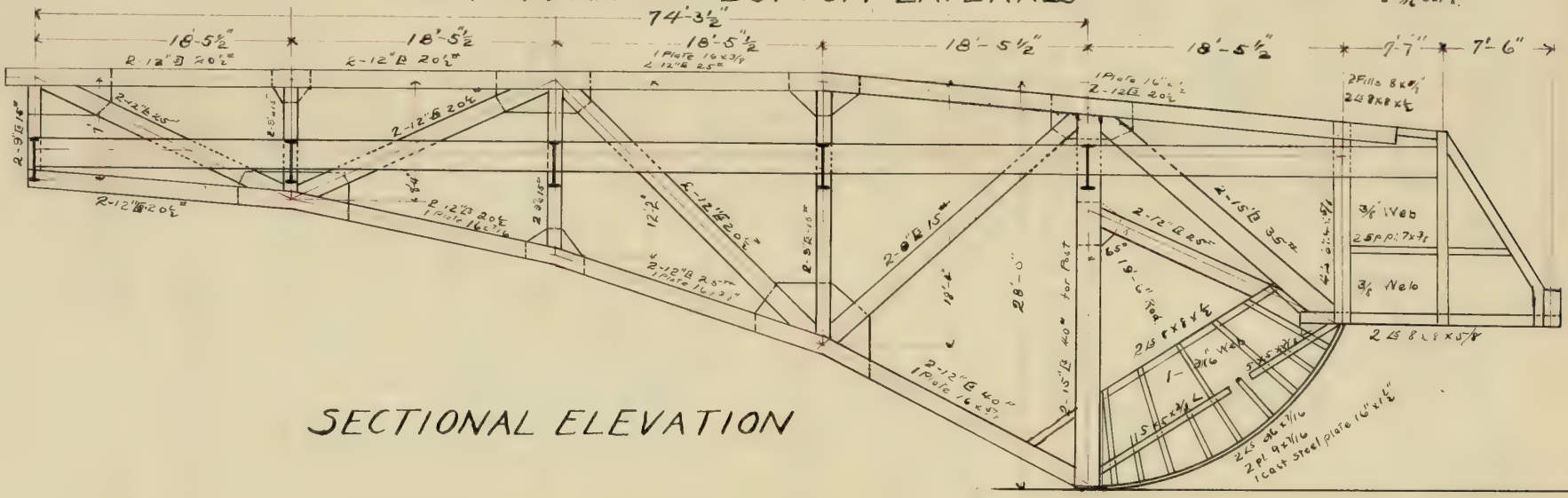
Plate I, page 7, shows a plan of the floor and laterals, and a sectional elevation.

PLATE I

HALF FLOOR PLAN


20'-4" center to center of trusses
24" I 80#
Center Line of Bridge
7" I 15#
12" I 31½#
15" I 42#
15" I 42# these diagonals riveted to bottom of stringer
4L 3x2½x5/16 Laced
16" I 65#
u-a-a- Struts between Segments
4L-3x2½x3/8
Lacing 2½x2½x5/16 L's 2½x5/16 Bars.

HALF PLAN OF BOTTOM LATERALS



SECTIONAL ELEVATION

WEIGHT OF BRIDGE

The weight of the main trusses (the portion of the bridge spanning the clear waterway) were computed as shown on pages 9 – 13. The numbers in the first column refer to the number of the piece as given on the stress sheet, Plate II page 26. The weight of the main truss is summarized on page 14. In computing the stresses, the weight was considered as a uniform dead load.

The weights of the several members of the counterweight trusses are given on pages 15 – 17. Owing to the peculiar distribution of this load, it was improper to treat it as a uniform dead load and therefore the weights of the different sections were divided proportionately between the different panel points.

WEIGHT OF MAIN TRUSSES

REF. No.	MEMBERS	No.	LENGTH	CROSS SECTIONS	WEIGHT per LIN. FOOT	TOTAL WEIGHT MAIN MEMBERS	TOTAL WEIGHT DETAILS
1	Channels	4	7.00	9"	15.0#	420	
	Gussets	4	1.67	15" x 5/16"	16.0		106
	Plates	2	2.00	14" x 5/16"	15.0		60
	Plates	4	1.17	12" x 5/16"	128		57
	Lacing	6	1.20	2" x 5/16"	2.54 pc.		15
	Plates	2	3.00	8 1/2 x 5/16"	9.2		51
	Angles	8	3.00	3" x 3" x -1/2"	7.2		172
	Rivets	82		3/4" ϕ	32# per 100		26
						420	487
2	Channels	4	17.92	12"	20.5	1466	
	Lacing	86	1.20	2" x 5/16"	2.54		218
	Plates	6	1.25	12" x 5/16"	12.8		96
	Plates	2	1.25	9" x 5/16"	9.5		24
	Rivets	206		3/4" ϕ	32# per 100		66
	Gussets	4	5.08	30" x 5/16"	31.7		646
						1466	1050
3	Channels	4	19.71	12"	25#	1971	
	Lacing	16	1.20	2" x 5/16"	2.54 pc		193
	Plates	8	1.25	16" x 5/16"	17.0		170
	Gussets	4	2.15	23 1/2" x 5/16"	24.7		272
	Rivets	288		3/4" ϕ	32# - 100		92
						1971	727
4	Channels	4	37.71	12"	20.5	3090	
4	Lacing	178	1.20	2" x 5/16"	2.54		452
6	Plates	4	1.50	15" x 5/16"	16.0		96
	Gussets	4	4.33	28" x 5/16"	29.8		518
	Plates	8	1.25	12" x 5/16"	12.8		128
	Plates	4	1.08	8" x 5/16"	8.5		37
	Fills	4	2.42	12" x 1/8"	5.1		49
	Channels	4	3.5	12"	20.5		287
	Rivets	482	4.15	3/4" ϕ	32# - 100		154
	Plates	2	4.15	16" x 3/8"	20.4		194
						3090	1915
5	Channels	4	7.41	9"	15#	445	
	Gussets	4	1.5	13" x 5/16"	13.6		82
	Lacing	12	12.0	2" x 5/16"	2.54 pc		31
	Plates	2	1.17	12" x 5/16"	12.8		30
	Rivets	84		3/4" ϕ	32# - 100		27
						445	170

Ref. No.	Members	No.	Length	Cross Section	Weight per Lin. Foot	Total Weight Main Members	Total Weight Details
7	Channels	4	19.05	12" "	20.5	1560	
	Lacing	82	1.20	2" x 5/16	2.54 pc		208
	Plates	8	1.25	12" x 5/16"	32"-100		128
	Rivets	438		3/4" ø			140
						1560	476
8	Channels	4	11.95	12"	35#	1672	
	Lacing	92	1.20	2" x 5/16"	2.54 pc		234
	Plates	4	1.33	16" x 5/16"	17.0		91
	Gussets	4	4.5	27 x 5/16"	28.6		515
	Rivets	372		3/4" ø	32"-100		119
						1672	959
9	Channels	4	11.17	9"	15#	670	
	Lacing	16	1.20	2" x 5/16"	2.54		41
	Plates	4	1.17	12 x 5/16"	12.8		60
	Rivets	84		3/4" ø	32#-100		27
						670	128
10	Channels	4	19.54	12"	35#	2136	
	Lacing	88	1.20	2" x 5/16"	2.54 pc.		224
	Plates	4	1.33	16" x 5/16"	17.0		91
	Gussets	4	5.25	34" x 5/16"	36.2		759
	Rivets	344		3/4" ø	32#-100		110
						2136	1184
11	Channels	4	24.65	12"	20.5	2025	
	Lacing	116	1.20	2" x 5/16"	2.54 pc.		295
	Plates	8	1.25	16" x 5/16"	17.0		170
	Rivets	352		3/4" ø	32#-100		124
						2025	589

Ref. No.	Members	No.	Length	Cross Section	Weight per Lin. Foot	Total Weight Main Members	Total Weight Details
12	Channels	4	18.5	12"	35#	2594	
	Lacing	80	1.20	2" x 5/16"	2.54 pc.		203
	Plates	4	1.25	12" x 5/16"	12.8		64
	Plates	2	5.25	16" x 3/8"	20.4		214
	Gussets	4	4.17	22" x 5/16"	25.5		425
	Rivets	364		3/4" ϕ	32# per 100		116
						2594	1022
13	Channels	4	17.40	9"	15#	1044	
	Lacing	56	1.20	2" x 5/16"	2.54		142
	Plates	8	1.17	12" x 5/16"	12.8		112
	Rivets	224		3/4" ϕ	32#-100		72
						1044	326
14	Channels	4	18.54	12"	35#	2605	
	Lacing	86	1.20	2" x 5/16"	2.54		218
	Plates	4	125	12" x 3/8"	15.2		76
	Rivets	122		3/4" ϕ	32-100		39
	" "	136		1/8" ϕ	48.6-100		66
						2605	399
15	Channels	4	23.5	9"	15#	1410	
	Plates	8	1.17	12" x 5/16"	12.8		120
	Lacing	128	1.20	2" x 5/16"	2.54 pc.		325
	Rivets	316		3/4" ϕ	32#-100		105
						1410	540
16	Channels	4	19.98	12"	40#	3200	
	Plates	2	22.5	16" x 5/8"	34.0	1526	
	Plates	4	1.33	16" x 3/16"	17.0		90
	Lacing	34	1.20	2" x 5/16"	2.54		87
	Rivets	120		1/8" ϕ	48.6-100		59
	Rivets	324		3/4" ϕ	32-100		104
						4726	340

Ref. No.	Members	No.	Length	Cross Section	Weight per Lin. Foot	Total Weight: Main Members	Total Weight: Details
	Bottom Lateral System						
	Angles	8	12.67	3" x 3" x 3/8	7.2	730	
	Angles	4	12.71	4" x 4" x 3/8"	9.7	493	
	Angles	16	18.42	3" x 2 1/2" x 5/16"	5.5	1620	
	Plates	2	2.42	16" x 5/16"	17.0		82
	Plate	1	2.33	28" x 5/16"	29.8		70
	Plates	2	1.33	27" x 5/16"	28.7		76
	Plate	1	2.60	26" x 5/16"	27.7		72
	Plates	2	2.11	34" x 5/16"	34.0		184
	Plate	1	3.42	35" x 5/16"	35.1		120
	Plates	2	2.04	26" x 3/8"	33.2		136
	Angles	4	54.80	3" x 2 1/2" x 5/16"	5.5	1200	
	Angles	6	1.12	3" x 3" x 3/8"	7.2		48
	Angles	6	1.25	4" x 4" x 3/8"	9.7		73
	Rivets	354		3/4" ϕ	32#-100		134
	Plates	8	1.17	7" x 5/16"	7.5		70
	Lacing	8	2.53	2 1/2" x 2 1/2" x 5/16"	5.0		114
	Rivets	132		3/4" ϕ	32#-100		46
	Lacing	16	1.66	2 1/2" x 3/8"	3.2		87
	Lacing	18	1.25	2 1/2" x 5/16"	2.54		58
						4040	1368
	Floor Beams						
	I Beams	4	19.48	24"	100.#	7792	
	I Beam	1	19.48	24"	80.	1558	
	Web Plates	10	5.62	12" x 5/16"	12.8		720
	Angles	40	5.42	3" x 2 1/2" x 5/16	5.5		1194
	Fillers	20	1.50	3" x 5/16"	3.2		95
	Plates	10	0.58	6" x 5/16"	6.4		36
	Angles	20	0.58	3" x 3" x 3/8"	7.2		76
	Fillers	20	0.33	3" x 3/8"	4.2		28
	Angles	60	1.75	3" x 3" x 3/8"	7.2		756
	Angles	20	1.12	3" x 3" x 3/8"	7.2		167
	Rivets	500		3/4" ϕ	32.-100		160
						9350	3232

Ref. No.	Members	No.	Length	Gross Section	Weight Per Lin. Foot	Total Weight Main Members	Total Weight Details
	Joists						
	I Beams	6	18.83	7"	15#	1696	
	I Beams	2	18.83	12"	31.5	1158	
	I Beams	4	18.83	15"	42	2850	
	Angles	64	1.00	5" x 3½" x ⅜"	10.4		666
	Angles	32	0.75	5" x 3½" x ⅜"	10.4		250
	Plates	20	1.50	15" x 5/16"	16.0		480
	Plates	20	0.80	6 5/16" x 5/16"	6.8		109
	Rivets	1152		3/4" ϕ	32#-100		368
						5604	1873
	Floor Lateral System						
	Angles	8	24.5	3" x 2½" x 5/16"	5.5	995	
	Plates	16	1.17	12" x 5/16"	12.8		282
	Plates	4	1.83	7" x 5/16"	7.5		55
	Rivets	144		3/4" ϕ	32#-100		46
						995	383
	Sway Bracing						
	Angles	2	10.00	3" x 2½" x 5/16"	5.5	110	
	Angle	1	2.00	3" x 2½" x 5/16"	5.5	11	
	Plates	6	1.35	15" x 5/16"	16.0		135
	Angles	2	21.50	3" x 2½" x 5/16"	5.5	237	
	Angle	1	9.42	3" x 2½" x 5/16"	5.5	51	
	Angles	12	1.13	3" x 3" x 3/8"	7.2		98
	Angles	2	6.80	3" x 2½" x 5/16"	5.5	295	
	Angle	1	5.08	3" x 2½" x 5/16"	5.5	28	
	Plates	4	1.50	8" x 5/16"	8.5		51
	Plates	4	2.08	9" x 5/16"	9.5		77
	Plates	6	2.50	16" x 5/16"	17.0		255
	Rivets	243		3/4" ϕ	32#-100		78
						732	594

TIMBER FLOORING.

6" of oak flooring on roadway	35,000
2" of pine flooring on side walks	7,000
2 - 6"x8" Hubguards - 74'-Lg	1,500
6 - 4"x6" Nailing pieces 74'-Lg.	1,480
	44,980

4 Street Car Rails 74' Lg @ 8# per lin. ft. 2,500

SUMMATION OF WEIGHTS

MEMBERS	WEIGHT OF MAIN MEMBERS	WEIGHT OF DETAILS	TOTAL WEIGHT
1	210	244	907
2	733	525	2516
3	986	364	2698
4-6	772	479	5005
5	223	85	615
7	780	238	2036
8	836	480	2631
9	335	64	798
10	1368	592	3920
11	1013	295	2614
12	1297	511	3616
13	522	163	1370
14	1303	200	3004
15	705	270	1950
16	2363	170	5066
BOTTOM LATERAL SISTEM	4040	1368	5408
FLOOR BEAMS	9350	3232	12582
JOISTS	5604	1873	7477
FLOOR LATERALS	995	383	1378
SWAY BRACING	732	594	1326
		TOTAL WT.	73,917

Weight of Steel 73.917
Weight of Timber 45000
Weight of Rails 2500
Total Weight 121,417

Length of Main Truss = 74'-3½"

Dead Load per lin. ft. of Truss 818 lbs.

Dead Load used by Bridge Company in figuring Stresses was 820 lbs.

WEIGHT OF COUNTERWEIGHT TRUSSES

Ref. No.	Members	No.	Length	Cross Section	Weight Per Lin. Foot	Total Weight Main Members	Total Weight Details
17	Channels	4	25.7	15"	40#	4056	
	Channels	2	13.0	15"	40#	1040	
	Plates	4	1.8	18" x 3/8"	23.0		166
	Plates	4	2.3	18" x 3/8"	23.0		206
	Plates	4	2.6	18" x 3/8"	23.0		240
	Plates	4	3.0	18" x 3/8"	23.0		276
	Angles	8	3.0	3 1/2" x 3" x 3/8"	7.8		188
	Plates	2	3.0	8 1/2" x 3/8"	11.0		66
	Plates	4	1.5	16" x 3/8"	20.4		122
	Plates	4	4.75	38" x 1/2"	64.5		1224
	Plates	4	5.0	52" x 1/4	44.2		884
	Angles	4	3.5	7" x 3 1/2" x 5/8"	28.8		232
	Angles	4	4.3	3 1/2" x 3 1/2" x 5/8	13.5		296
	Angles	4	2.5	3" x 5" x 5/8	9.7		288
	Rivets	1800		3/4" ϕ	16-100		
						2548	2143
18	Angles	4	16.3	8" x 8" x 1/2"	26.35	1720	
	Web Plate	2	140 sq ft.	9/16"	23.0	6444	
	Fills	4	5.5	3 1/2" x 7/16"	5.2		114
	Fills	4	4.5	3 1/2" x 7/16"	5.2		94
	Angles	4	6.0	7" x 3 1/2" x 9/16"	19.0		456
	Fills	4	4.7	3 1/2" x 7/16"	5.2		96
	Fills	4	5.7	3 1/2" x 7/16"	5.2		118
	Angles	4	6.2	6" x 3 1/2" x 1/2"	15.3		380
	Angles	2	2.1	6" x 6" x 3/8"	15.0		34
	Angles	16	3.75	6" x 3 1/2" x 1/2"	15.3		920
	Fills	16	3.25	3 1/2" x 7/16"	5.2		270
	Fills	16	3.00	3 1/2" x 7/16"	5.2		250
	Fills	10	2.0	7 1/4" x 7/16"	10.4		208
	Fills	8	7.0	3 1/2" x 7/16"	5.2		292
	Fills	8	6.1	3 1/2" x 7/16"	5.2		254
	Angles	8	7.5	6" x 3 1/2" x 1/2"	15.3		918
	Angles	4	1.0	3" x 3" x 3/8"	7.2		30
	Fills	4	6.5	3 1/2" x 7/16"	5.2		136
	Angles	4	7.8	6" x 3 1/2" x 1/2"	15.3		480
	Fills	4	7.3	3 1/2" x 7/16"	5.2		152
	Fills	4	2.7	3 1/2" x 7/16"	5.2		56
	Fills	4	6.0	3 1/2" x 7/16"	6.2		126
	Fills	4	4.5	3 1/2" x 7/16"	5.2		94
	Angles	4	6.0	6" x 3 1/2" x 1/2"	15.3		368
	Angles	4	33	6" x 3 1/2" x 1/2"	15.3		202

Ref. No.	Members	No.	Length	Cross Section	Weight per Lin. Foot	Total Weight Main Members	Total Weight Details
18	Continued.						
	Plates	4	22.9	9" x 7/16"	13.6		1240
	Angles	4	22.9	6" x 6" x 7/16"	17.2		1600
	Plates	2	24.73	16" x 1 1/2"	81.5	4040	
	Angles	4	3.0	7" x 3 1/2" x 9/16"	19.0		228
	Fills	4	3.8	17" x 1/16"	3.5		54
	Sp. Plate	4	4.2	28" x 3/8"	35.7		600
	Angles	4	3.25	7" x 3 1/2" x 9/16"	19.0		486
	Rivets	2000		7/8" ø	24.3-100		486
						10204	10524
19	Channels	4	21.0	15"	35#	1470	
	Plates	8	1.5	16" x 3/8"	20.4		244
	Rivets	1240		3/4" ø	16-100		200
	Lacing	72		2 1/2" x 5/16"	2.5-pc.		180
						1470	312
20	Channels	4	20.0	12"	25#	2800	
	Plates	4	1.30	12" x 3/8"	15.2		78
	Lacing	90		2 1/2" x 5/16"	2.5-pc.		226
	Rivets	400		3/4" ø	16-100		64
						2800	368
21	Angles	8	11.0	6" x 4" x 5/8"	19.9	1760	
	Rivets	360			16-100		58
						1760	58
22	Angles	4	19.25	8" x 8" x 5/8"	33.0	2530	
	Fills	4	17.5	8" x 1/8"	3.4		238
	Rivets	400		3/4" ø	16-100		64
						2530	302
	Radial Member						
	Channels	4	13.2	12"	25	1320	
	Plates	4	3.0	18" x 3/8"	23.0		276
	Plates	4	2.20	18" x 3/8"	23.0		202
	Plates	4	1.3	18" x 3/8"	23.0		120
	Rivets	840		3/4" ø	16-100		134
	Channels	2	6.25		25		312
	Gussets	6	3.25	27" x 9/16"	44.0		860
						1320	1904

Ref. No.	Members	No.	Length	Cross Section	Weight per Lin. Ft.	Total Weight Main Members	Details
23	Web Plate	2	13.25	90" × 3/8"	115.0	3042	
	Web Plate	2	19.6	60" × 3/8"	87.0	3400	
	Sp. Plates	4	6.8	7" × 3/8"	9.0		246
	Fillers	4	10.4	6 1/2" × 5/8"	13.8		570
	Angles	8	11.75	3" × 3" × 3/8"	7.2		680
	Angles	4	2.3.	7" × 3 1/2" × 9/16"	19.0		175
	Sp. Plates	4	4.3	7" × 3/8"	9.0		154
	Angles	4	11.3	8" × 8" × 1/2"	26.4		1192
	Fillers	4	11.3	8" × 5/8"	17.0		770
	Plates	4	225	14" × 1/2"	23.8		234
	Fillers	4	2.2	24" × 5/8"	51.0		458
	Fillers	2	2.25	14" × 3/8"	17.8		158
	Angles	8	0.5	6" × 4" × 3/8"	12.3		50
	Angles	4	1.0	8" × 8" × 1/2"	26.4		106
	Angles	8	1.65	8" × 6" × 1/2"	24.7		326
	Angles	4	2.8	6" × 3 1/2" × 3/8"	11.4		128
	Fillers	4	1.0	10" × 1/2"	17.0		68
	Fillers	4	1.6	3 1/2" × 1/2"	6.0		40
	Oak Blocks	4	1.4	8" × 12 1/2"			170
						6442	5525
	Segment Struts and Laterals						
	Angles	12	20.3	3" × 2 1/2" × 5/8"	6.5	1580	
	Angles	4	3.0	3" × 3" × 3/8"	7.2		86
	Lacing	44	2.0	2 1/2" × 5/16"	2.5 - pc.		115
	Lacing	26	2.0	2 1/2" × 2 1/2" × 3/16"	5.9		248
	Plates	6	3.0	20" × 3/8"	29.4		528
	Angles	4	12.7	5" × 5" × 3/8"	12.3	312	
	Angles	2	11.5	3" × 2 1/2" × 5/16"	5.5	126	
	Angles	4	20.2	3" × 2 1/2" × 5/16"	5.5	444	
	Rivets	100		3/4" ϕ	16 - 100		16
						2462	993
	Floor Beam and Stringers						
	Web	1	20.25	41 3/4" × 5/16"	44.2	895	
	Fills	4	2.8	3" × 1/2"	5.1		57
	Angles	4	3.4	3" × 3 1/2" × 3/8"	7.8		106
	Plates	4	2.8	5/2" × 5/16"	7.4		83
	Angles	4	19.6	7" × 4" × 1/2"	12.8		
	I Beams	6	25.0	7"	15#	1000	
	I Beams	4	25.0	15"	42#	2250	
	I Beams	2	250	12"	31 1/2#	4200	
	Rivets	500		3/4" ϕ	16 - 100	1575	
						9920	80
						9920	326
	Sway Bracing						
	Angles	2	20.25	3" × 2 1/2" × 5/16"	5.5	220	
	Angle	1	2.0	3" × 2 1/2" × 5/16"	5.5		11
	Plates	2	1.5	11" × 5/16"	11.2		33
	Plates	4	1.7	16" × 5/8"	20.4		139
	Rivets	160		3/4" ϕ	16 - 100		26
						220	209

I. STRESSES IN MAIN TRUSS

Due to Dead Load. In figuring the stresses in the members of a main truss of a rolling lift bridge, we must consider the two cases of the bridge closed and the bridge open. In the first case the stresses were computed by graphical resolution as in an ordinary cantilever truss. The stresses were found on a large scale diagram which is not shown. Plate II, page 26, shows a reduced form of this diagram and also shows the stresses.

In the second case, on account of the riveted connections, we cannot distribute the load and hence cannot use the method of graphical resolution. However, we can assume the most unequal distribution of the dead load and prove

that the stresses induced by this distribution can not exceed those due to the live and dead loads together when the bridge is closed. The weight of the main truss does not exceed one hundred and twenty-two thousand pounds which must be carried to the abutment through the members in the panel next the segmental girder. As the most extreme case we shall consider that the entire load is borne in compression by member 16, Plate VII, page 35, and that we have an additional stress equal to fifty per cent of the dead load, due to the balancing of the arm. There is then a stress of 183,000 pounds in member 16 but the combined dead and live load stresses when the bridge is closed amounts to 265,000 pounds. In this way it can

be shown that the members of the main truss are never under maximum stress when the bridge is opened.

Stresses Due to Live Load. The bridge is designed for a live load of one hundred pounds per square foot of roadway and sidewalks, and in computing the stresses due to this live load, three positions of the live load must be considered:

Case I. Live load covering the entire bridge. The method of determining the stresses in this case is precisely similar to that of the dead load. Plate III, page 27, shows the reduced form of the diagram employed in finding the stresses, and also the stresses.

Case II. Live load extends from the panel under consideration to the remote

abutment. According to the principles of the design, part of the load on the loaded arm is transmitted through the shear lock to the unloaded arm and thence to the unloaded abutment. The effect of the shearlock in transmitting the load has an important bearing upon the method of finding the stresses in the members of the unloaded arm.

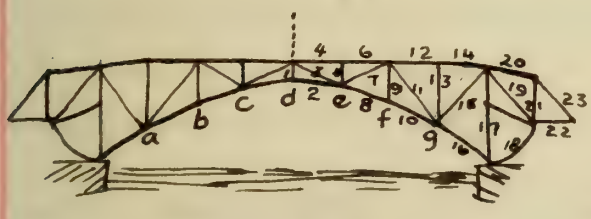


Fig. 1

To find the stresses in the members of panel de, Fig. 1, consider the bridge loaded from the left to and including the joint d. There is then acting upon the shear lock, the shear and the stresses in members 3 and 4. The position and direction of these three forces are shown in Fig. 2. The stresses are most easily found

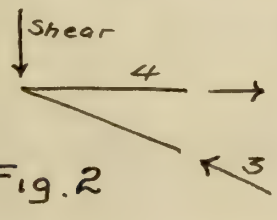


Fig. 2

by graphical resolution as is shown in Plate IV, page 28.

To find the stresses in the panel e f, Fig. 1, consider the bridge loaded from the left abutment to and including the joint e. In this case it is not possible to find the stresses in the three members 6, 7, and 8, by placing the shear in the panel equal to the vertical component of the pieces cut, since there are three unknown forces. Therefore it is necessary ~~to find~~ first the stress transmitted through the shear lock. For this loading, the shear at d is equal to the portions of the loads at a, b and c which are supported at the right abutment, minus the portion of the load e which is supported at the left abutment. To find the stresses in pieces 6, 7 & 8, pass a

vertical plane through these pieces and consider the members between this plane and the shear lock. The forces acting are shown in Fig. 3. A reduced

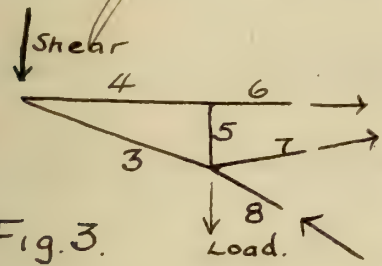


Fig. 3.

form of the diagram used to find the stresses and also the stresses are shown in Plate IV, page 28.

In a similar manner the stresses in pieces 10, 11, and 12 are found. A reduced form of the diagram used in finding these stresses is shown on Plate IV.

There is no need of figuring the stresses in the members of panel gh or the vertical posts since for this case the bridge will be uniformly loaded and those stresses have already been worked out.

Case III. Live load covers one arm.

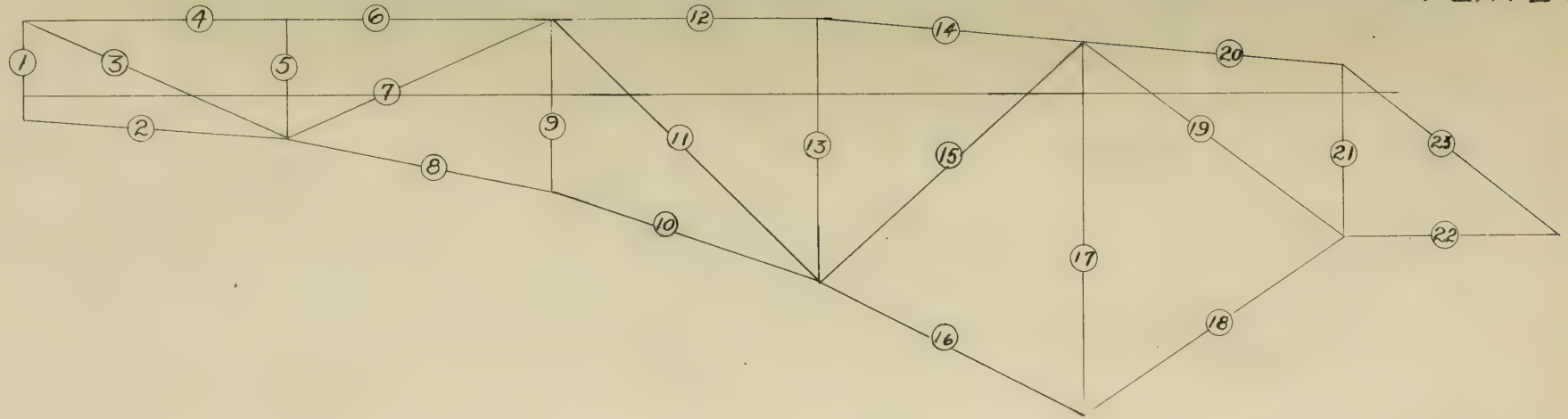
In this case there must be considered the reversal of stress in some of the members of the loaded chord due to the reaction of the shear lock; that is, when but one arm is loaded, it may be considered as a fixed span supported by the abutment and the pin connecting it with the unloaded arm. In this case the reaction is upward instead of downward as in the former case. The stresses are found by substantially the same method as in Case II. Plate III, page 27, shows a reduced diagram for finding the stresses.

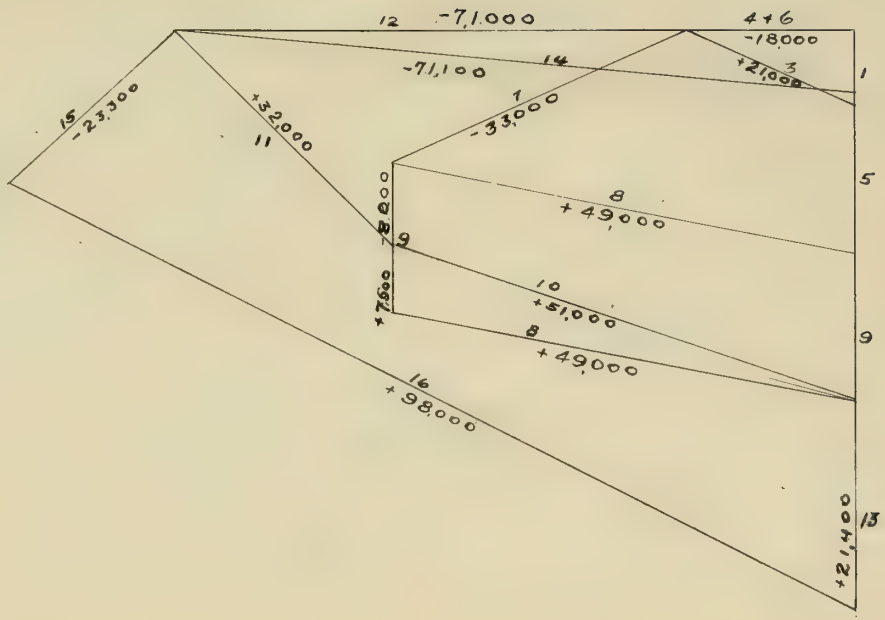
It is not necessary to find the stresses in the other members since they will be less than the stresses in Cases I & II.

WRITER'S VS. DESIGNER'S RESULTS

Plate V, page 29, shows the stresses in the main truss as obtained by the writer and also those obtained by the Sheyer Bridge Company. The differences are permissible by the method employed in figuring the stresses.

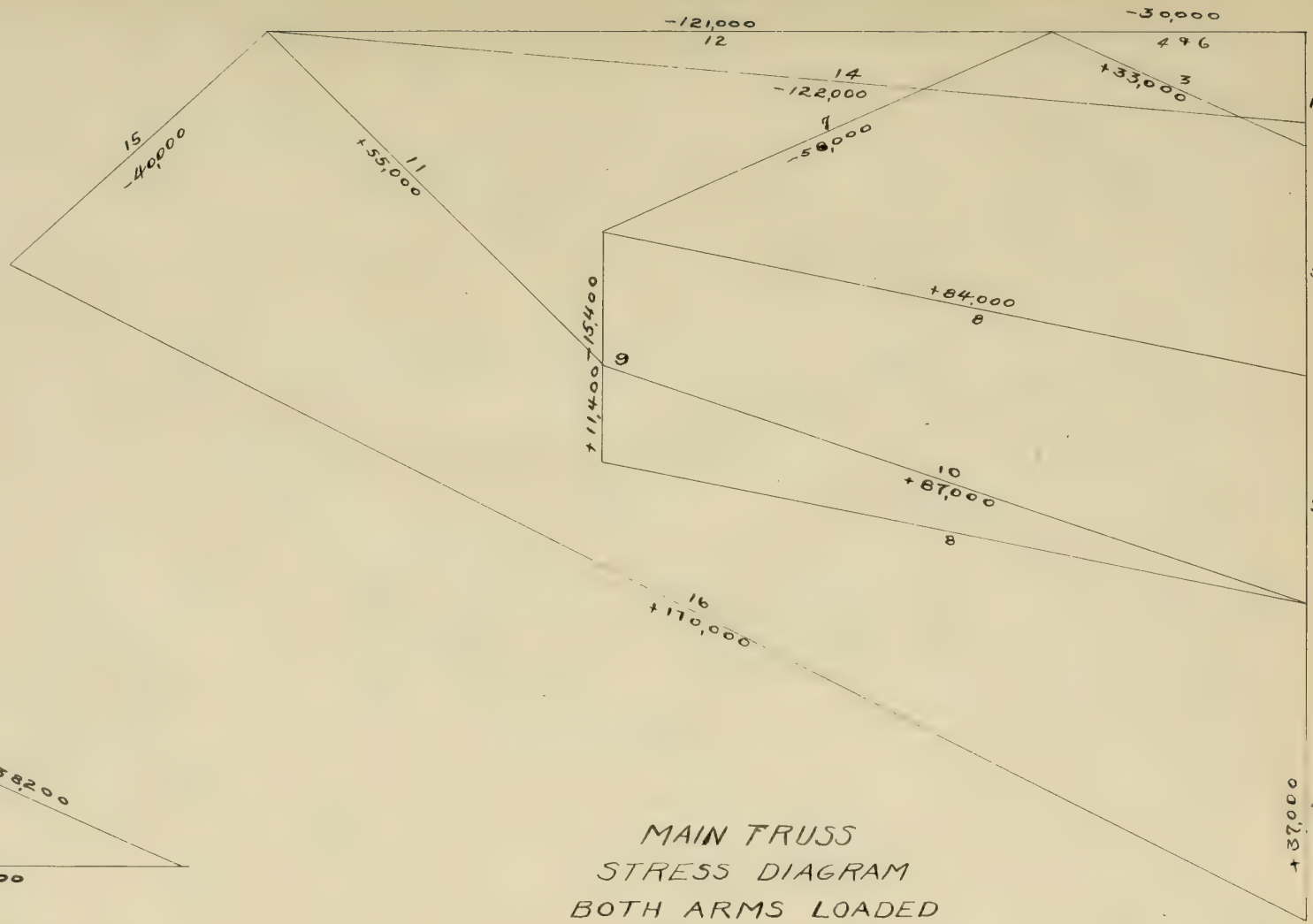
PLATE II



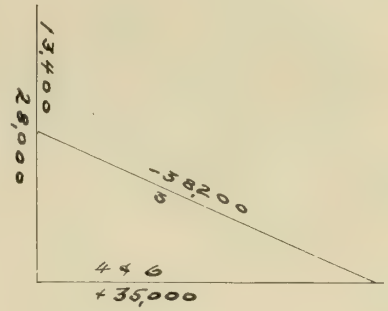


MAIN TRUSS
STRESS DIAGRAM
FOR DEAD LOADS
SCALE-1/N=20,000LBS.

PLATE III

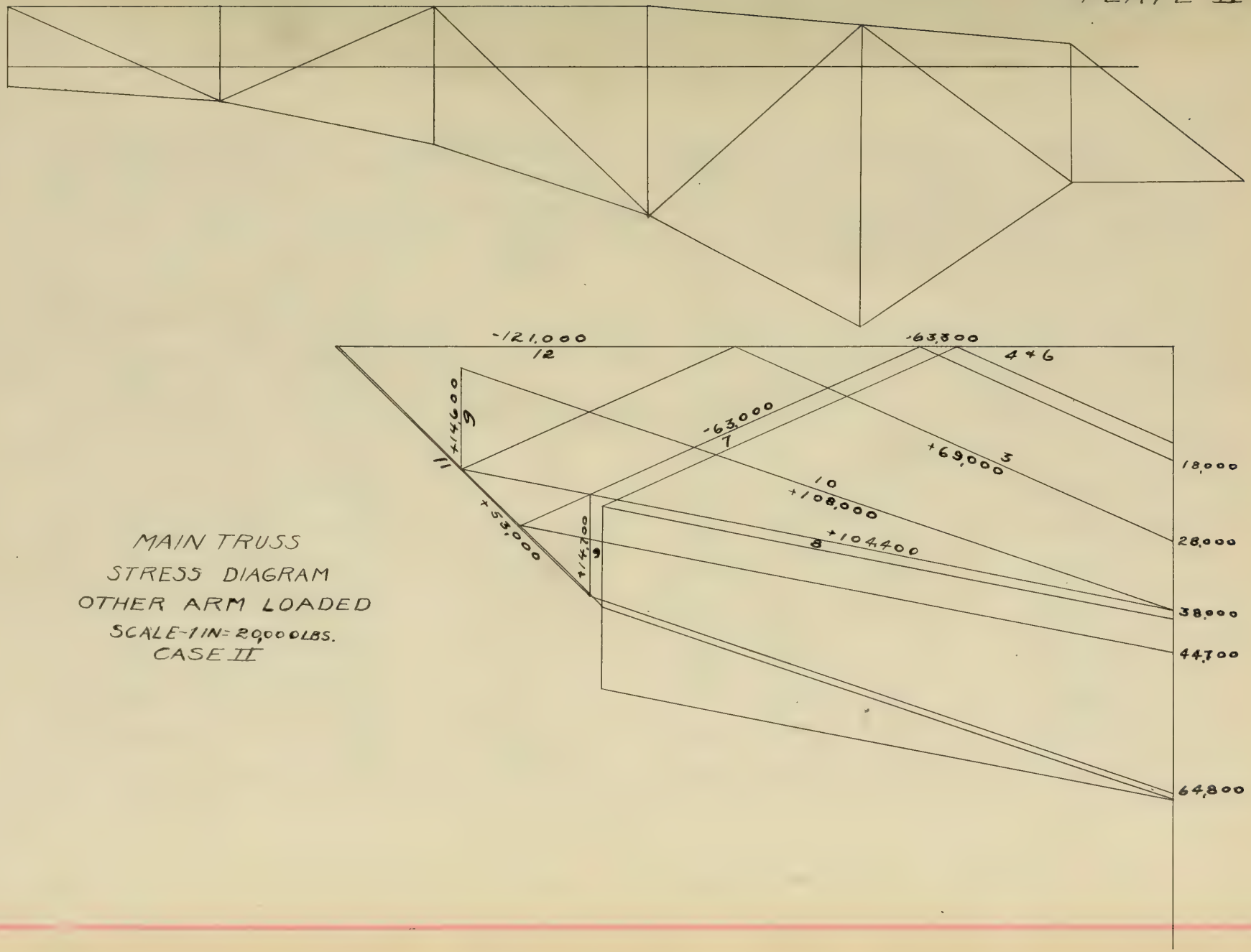


MAIN TRUSS
STRESS DIAGRAM
BOTH ARMS LOADED
SCALE-1 IN=20,000 LBS.
CASE I



STRESS DIAGRAM
OTHER ARM UNLOADED
CASE III

PLATE IV



MAIN TRUSS
STRESS DIAGRAM
OTHER ARM LOADED
SCALE-1 IN = 20,000 LBS.
CASE II

PLATE V

COMPARISON OF STRESSES IN THE MAIN TRUSS

MEMBER	STRESSES FIGURED BY BRIDGE COMPANY						STRESSES FIGURED BY AUTHOR					
	DEAD LOAD	LIVE LOAD CASE I	LIVE LOAD CASE II	LIVE LOAD CASE III	TOTAL MAX STRESSES		DEAD LOAD	LIVE LOAD CASE I	LIVE LOAD CASE II	LIVE LOAD CASE III	TOTAL MAX STRESSES	
1	+8,700	+14850	-14850		-23,550		-8,000	-14,150	-14,150		-22,150	
2	0	0	0				0	0	0			
3	+21,800	+37,250	+71,000	-40,200	+92,800	-18,400	+21,000	+33,000	+69,000	-38,200	+90,000	-17,200
4	-20,000	-34,200	-65,000	+37,000	-85,000	+17,000	-18,000	-30,000	-63,300	+35,000	-81,300	+17,000
5	+15,200	+26,000	+26,000	+26000	+41,200		+15,200	+26,800	+26,800	+26,800	+42,000	
6	-20,000	-34,200	-65,000	+37,000	-85,000	+17,000	-18,000	-30,000	-63,300	+35,000	-81,300	+17,000
7	-34000	-58,100	-63,000		-97000		-33,000	-58000	-63,000		-96,000	
8	+52,000	+89,000	+104,000		+156000		+49,000	+84,000	+104,400		+153,400	
9	+8,000 +7.200	-13,700 +12,300	+15000		+22,200	+21,700	-8,000 +7,200	-15,400 +11,400	+14,700		+21,900	-23,400
10	+54000	+92,400	+108,000		+162,000		+51,000	+87000	+108,000		+159,000	
11	+30,500	+52,200	+53,000		+83,500		+32,000	+55,000	+53,000		+87,000	
12	-72,500	-124,000	-125,000		-197,500		-71,000	-121,000	-121000		-192,000	
13	+21,000	+36000	+36,000		+57,000		+21,400	+37,000	+37,000		+58,400	
14	-72,600	-121,000	-121,000		-199,600		-71,100	-122,000	-122,000		-193000	
15	-23000	-39000	-39,000		-62,400		-23,300	-40,000	-40,000		-63,300	
16	+101,000	+165,000	+165,000		+266,000		+98,000	+170,000	+170,000		+268,000	

II. STRESSES IN COUNTERWEIGHT TRUSS

Due to Dead Load. The dead load stresses in the counterweight truss must be figured for the two cases of bridge closed and bridge open. In the first case the weights of the several members and also the weight of the counter-poise was distributed among the different joints to the best of the writer's judgement. The position of the counter-poise is represented by ABC in Fig. 4. The total counterweight is 85,000 pounds which the writer assumed to be distributed as follows: at A 25,000 pounds, at B 40,000 pounds, and at C 20,000 pounds. The resulting stresses were found by graphical resolution, a reduced form of the diagram used being

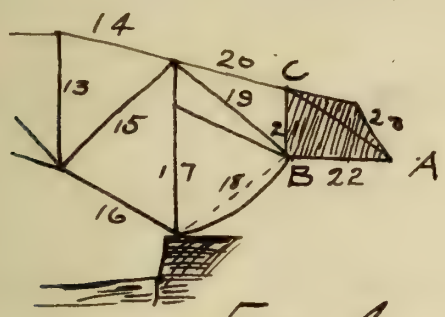


Fig. 4.

shown on Plate VI, page .

In the second case, i.e., when the position of the leaf is almost vertical it was impossible to find the stress in piece 17, Plate VII, page 35, without making some assumption as to the action of the main truss on the adjoining members of the counterweight truss. It was assumed that there would be no change in the stresses in the counterweight truss if we considered the main truss as replaced by a simple triangular truss with its highest point at the center of gravity of the main truss and the other two points at D and E. The weight of the main truss was then considered as acting at its center of gravity, and the stresses in 17, Plate VII, were found. It was also necessary to make a different distribution of the

counterweight. This time sixty-five per-cent of the counter poise was considered as acting at C and thirty-five per cent at B. Plate VII, page 35 shows a reduced form of the diagram used in obtaining the stresses.

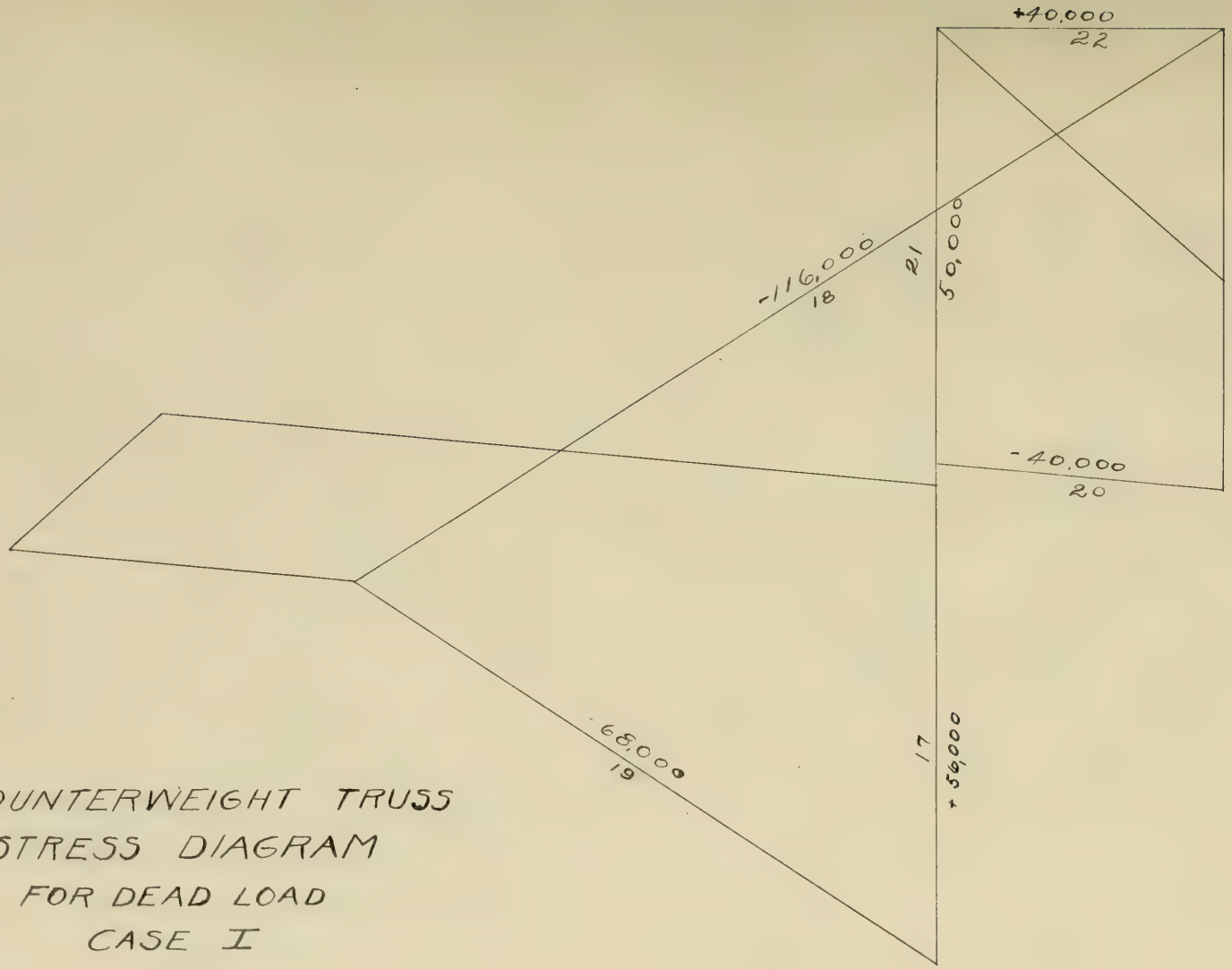
Stress Due to Live Load. The bridge is designed to carry the live load to an anchorage at the rear of the abutment, and to compute the stresses it was necessary to find the maximum strain on the anchorage. To determine this, the main truss was considered loaded with the maximum live load, and the strain on the anchorage necessary to balance this was assumed as the maximum. The stresses due to the live load were solved by graphical resolution. Plate VIII, page 36 shows a

reduced form of the diagram used.

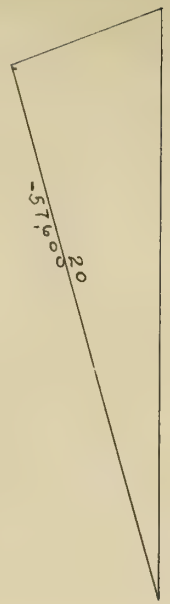
WRITER'S VS. DESIGNER'S RESULTS

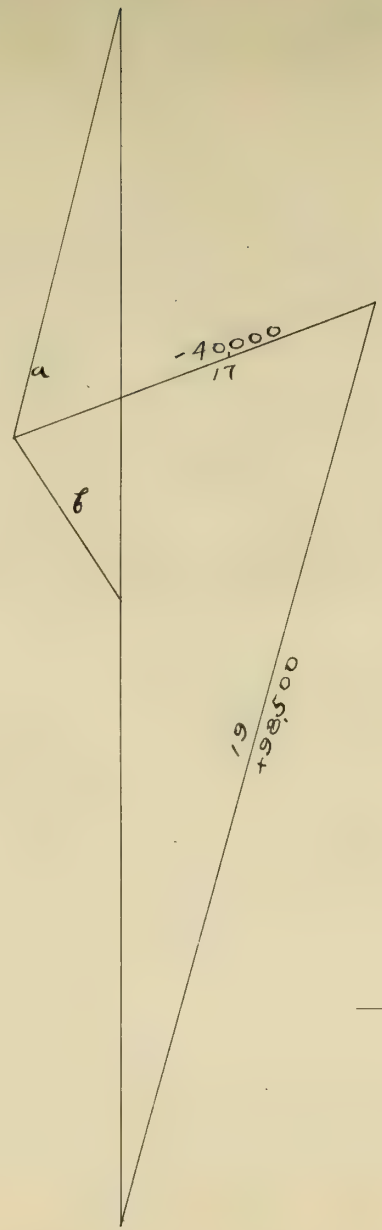
Plate IX, page 37, shows the results obtained by the writer and those given by the designer. These results do not agree as closely as those obtained for the main truss, owing probably to the difference in the assumptions as to the distribution of the weight of the counterpoise.

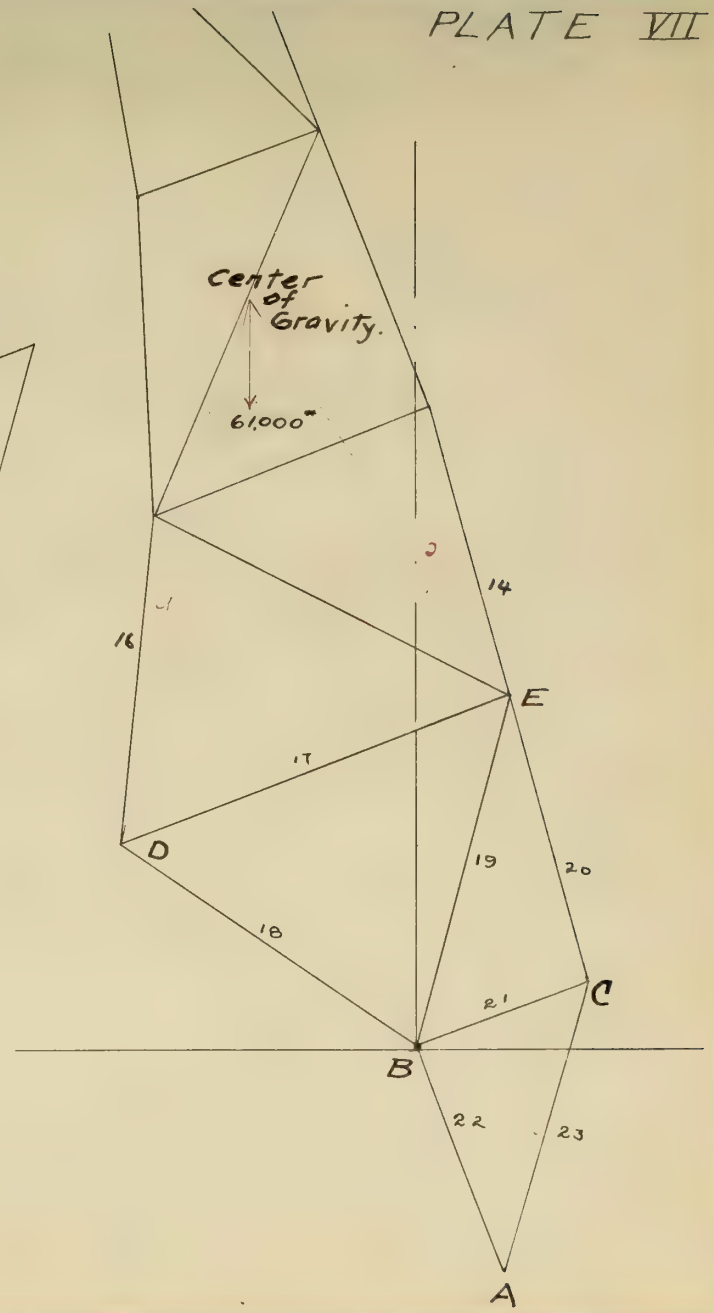
PLATE VI



COUNTERWEIGHT TRUSS
STRESS DIAGRAM
FOR DEAD LOAD
CASE I

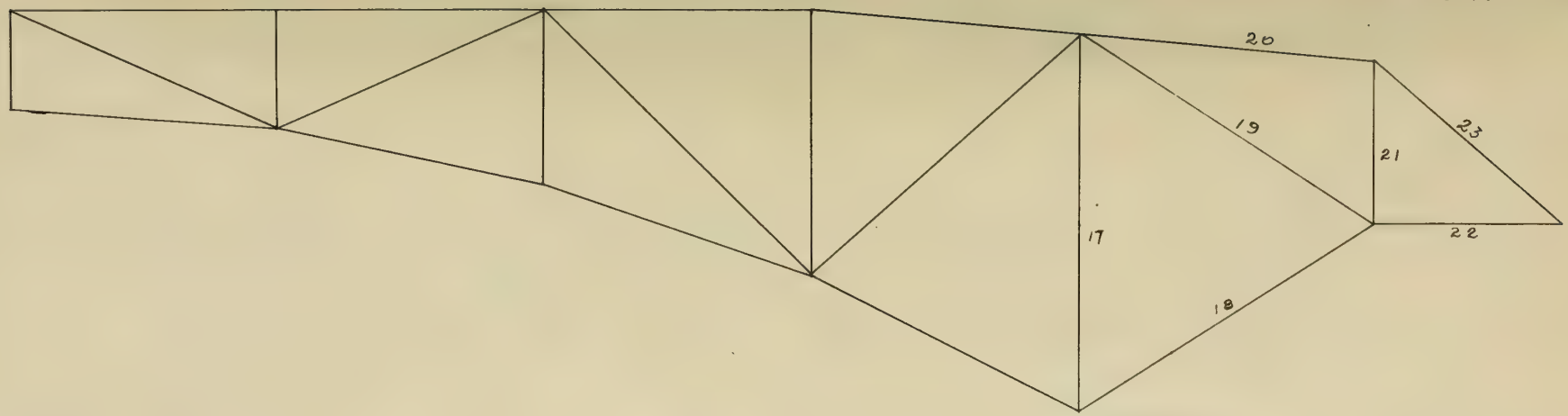


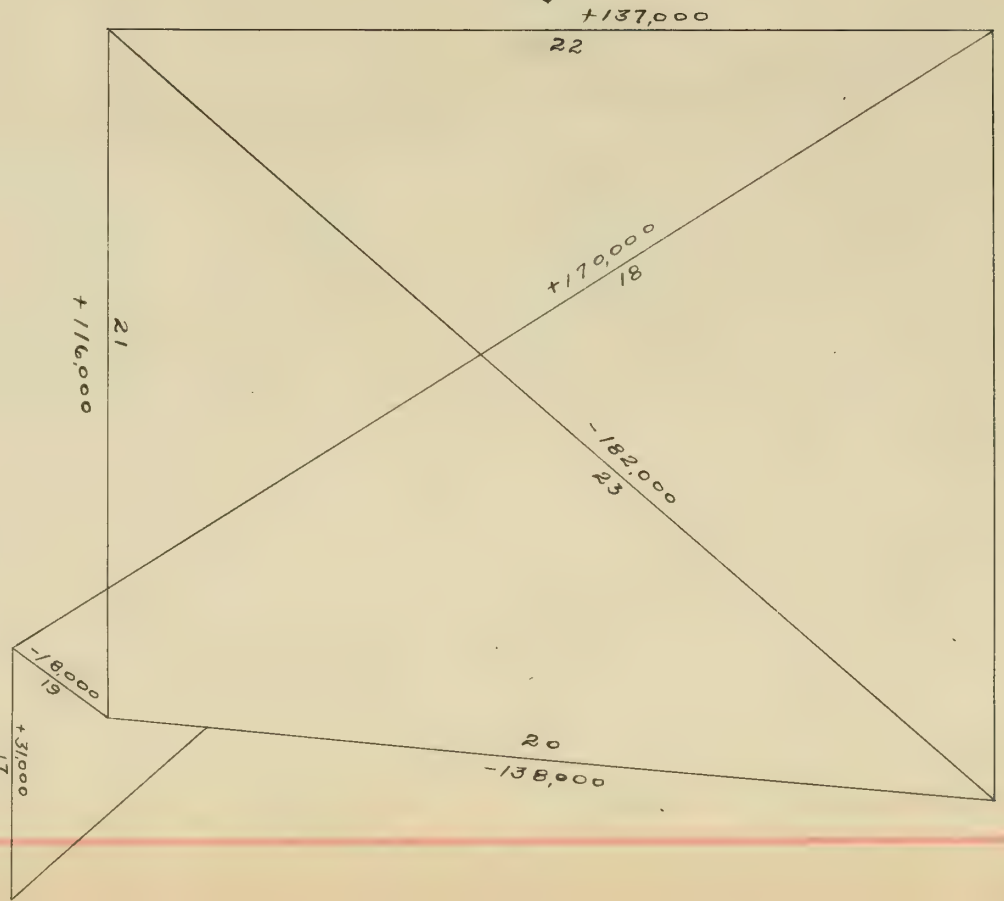




COUNTERWEIGHT TRUSS
STRESS DIAGRAM
FOR DEAD LOADS
CASE II

PLATE VIII





COUNTERWEIGHT TRUSS
STRESS DIAGRAM
FOR LIVE LOAD

PLATE IX

COMPARISON OF STRESSES IN THE COUNTERWEIGHT TRUSS

MEMBER	STRESSES OF BRIDGE Co.					AUTHOR'S STRESSES				
	DEAD LOAD		LIVE LOAD,	TOTAL MAX. STRESSES		DEAD LOAD		LIVE LOAD	TOTAL MAX. STRESSES	
	CASE I	CASE II	UNIFORM			CASE I	CASE II	UNIFORM		
17	+78,000	-47,000	+58,000	+136,000	-47,000	+71,000	-40,000	+45850	+116,850	-40,000
18	+115,000		+178,000			+116000		+170,000		
19	-69,000	+98,000	-27,000	+98,000	-96,000	-68,000	+98,500	-18,000	+98,500	-86,000
20	-40,000	-58,500	-146,000	-186,000		-40,000	-57,600	-138,000	-178,000	
21	+60,000		+114,000	+174,000		158000		+116,000	+174,000	
22	-40,000		+137,000	+177,000		+40,000		+137,000	+177,000	
23			-182,000	-182,000				-182,000	-182,000	

III OPERATING MACHINERY

The devices employed for opening and closing the bridge are important features, but the time available for this thesis did not warrant taking up that phase of the subject.

ADVANTAGES OF THE ROLLING LIFT BRIDGE

In closing, the author desires to call attention to some of the advantages of this type of movable bridge.

The rolling lift bridge is cheapest in first cost. With one exception this type offers the shortest possible span. The Page bascule, a recent and as yet untried trunnion bascule bridge, has a shorter span. The swing bridge on account of its center pier obstructing the channel, requires a greater span to provide sufficient water-way. The rolling lift principle allows the point of support of the leaf when closed to fall nearer the edge of the abutment than in the trunnion bascule type, which means a shorter span and a decreased cost of bridge. Bascule

bridges are cheaper to erect than swing bridges. In the erection of a bascule bridge, false-work is built up around the position the bridge takes when open. This method of erection interferes in no way with navigation and removes the necessity of the more expensive false work required in the case of a bridge put in place over the channel. Among all the bridges erected by the city of Chicago, the Taylor Street rolling lift bridge, in proportion to its capacity, was cheapest in first cost.

The rolling lift bridge is cheapest in cost of maintenance. The balancing of the main truss by counterweights reduces to a minimum the force required to lift the bridge, and it is a well-established fact that the friction of

rolling on a segment is much less than the friction of a similar mass about a pin. It is evident then that less power will be required to operate the rolling lift type.

The rolling lift bridge furnishes an unobstructed channel, and does not render useless the adjacent dock-space. The center pier of a swing bridge blocks the central and most efficient part of the channel both for navigation and for flow of water. If the center piers on one bank, it practically destroys the value of all the dock space covered by the bridge in its swing. These features increase the economic importance of the rolling lift type.

The rolling lift bridge requires the least time for operation. The

value of the time required for the operation of a movable bridge is a factor which increases with the amount of navigation and street traffic, and in a city like Chicago requires careful consideration. The Metropolitan Railway bridge requires but thirty seconds to open or close it, and after starting to close, it is ready to receive trains in less than one minute. This bridge is at least fifty per cent quicker of operation than the trunnion bascule or the swing bridge.

The rolling lift bridge provides a visible and effective barricade to street traffic. This advantage is readily seen and appreciated by all who have seen this bridge in operation. When opening, the leaves of the bridge

roll back till the floor blocks the highway like an almost vertical wall. Accidents on account of open draws are affairs of frequent occurrence, and a style of bridge that will prevent this kind of accidents possesses a value from a humanitarian standpoint. This office is performed by this bridge more effectively than by any other.

This type of bridge is readily applicable as a through, deck, or double-deck bridge. It can therefore provide for a crossing at any height from the level of the surface cars to the level of the elevated railways.

The rolling lift bridge can be built any width desired. This is accomplished by coupling together any number of leaves and having them work as one leaf. In case of accident to any leaf it can be

uncoupled and swung back to a vertical position while the other leaves are used independently. It is readily seen that the width of a swing bridge is limited by the width of the channel, and that when broken it must prove an obstruction either to street traffic or to navigation.

The rolling lift bridge can not roll off of its foundations. It is so counter-weighted that when the inter locking pins are withdrawn, the leaves will balance at an angle of forty degrees with the horizontal, and if the leaf were to drop from a vertical position, it would fall until it passed this angle of rest and then slowly oscillate up and down till it came to rest at this angle.